

# **METHOD AND APPARATUS FOR AUTOMATING TESTING OF JAVA BEANS**

## **FIELD OF THE INVENTION**

5           This invention relates to software testing in general, and more specifically to a tool for automating the testing of any given Java Bean.

## **BACKGROUND OF THE INVENTION**

Object oriented programming languages such as Java are frequently used in a  
10   variety of applications. These applications include programs for use on personal computers as well as complex systems such as those used in Computer Telephony Integration (CTI) networks. In a CTI system, applications written using Java interface with a CTI server to interact with a switch or Automatic Call Distributor (ACD). Object oriented languages such as Java are popular for use in such applications because of their  
15   ease of maintenance and expandability. However, testing of new or revised software is a time consuming and therefore expensive process.

In order to test a new or revised program, a programmer is generally required to write a test script or test program which is specific to a particular switch. Such a script or program may include commands to test the functionality of a switch, and possibly  
20   provide means for outputting results of the test. The technique of writing a switch specific testing program is time consuming and therefore costly.

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## BRIEF DESCRIPTION OF THE DRAWINGS

The appended claims set forth the features of the invention with particularity. The invention, together with its advantages, may be best understood from the following detailed description taken in conjunction with the accompanying drawings of which:

5           Figure 1 is an example of a typical computer system upon which one embodiment of the present invention may be implemented;

Figure 2 is a block diagram illustrating a conceptual view of a Java Bean testing tool for a computer system according to one embodiment of the present invention;

10           Figure 3 is an example of a typical computer telephony integration network system upon which one embodiment of the present invention may be implemented;

Figure 4 is a block diagram illustrating a conceptual view of a Java Bean testing tool for a computer telephony integration server according to one embodiment of the present invention;

15           Figure 5 is an example of an input file according to one embodiment of the present invention;

Figure 6 is an example of a bean event log file according to one embodiment of the present invention;

Figure 7 is an example of a script execution log file according to one embodiment of the present invention;

20           Figure 8 is a flow chart illustrating a Java Bean testing process according to one embodiment of the present invention;

Figure 9 is a flow chart of a class for handling events according to one embodiment of the present invention;

Figure 10 is a flow chart of a class for adding an object according to one embodiment of the present invention;

5        Figure 11 is a flow chart of a class for loading Java Beans according to one embodiment of the present invention;

Figure 12 is a flow chart of a class for running Java Beans according to one embodiment of the present invention;

10       Figure 13 is a flow chart of a class for reading an input file according to one embodiment of the present invention;

Figure 14 is a flow chart of a class for writing a log file according to one embodiment of the present invention; and

Figure 15 is a flow chart of a class for creating a user defined object according to one embodiment of the present invention.

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5 programming to be tested are required. According to one embodiment of the present invention, an automatic testing tool for generic Java Beans is provided. The tool tests any Java Bean given the path to this Bean and a list of APIs to be invoked.

According to one embodiment of the present invention, a Java Bean and a list of APIs and their parameters is read by the testing tool. Next, the Java Bean is located from the given path at runtime. If it does not exist at the given location an error is produced. The tool also checks to see if the given list of APIs exist in the Java Bean. If so, the given APIs are executed in the order they appear in the input file. The tool also recognizes some other keywords not existing in the Java Bean such as “sleep” and “loop”.

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computer by way of data signals embodied in a carrier wave or other propagation medium via a communication link (e.g., a modem or network connection).

Importantly, while embodiments of the present invention will be described with reference to automated testing of Java Beans interacting with a Computer-Telephony

5 Integration (CTI) server, the method and apparatus described herein are equally applicable to automated testing of other types of software on different types of platforms. For example, the techniques described herein are thought to be useful in connection with automating testing of other object oriented languages in systems such as personal computers. For example, similar techniques can be applied to automated testing of a DLL  
10 or an ActiveX control.

Figure 1 is an example of a typical computer system upon which one embodiment of the present invention may be implemented. Computer system 100 comprises a bus or other communication means 101 for communicating information, and a processing means such as processor 102 coupled with bus 101 for processing information. Computer system  
15 100 further comprises a random access memory (RAM) or other dynamic storage device 104 (referred to as main memory), coupled to bus 101 for storing information and instructions to be executed by processor 102. Main memory 104 also may be used for storing temporary variables or other intermediate information during execution of instructions by processor 102. Computer system 100 also comprises a read only memory  
20 (ROM) and/or other static storage device 106 coupled to bus 101 for storing static information and instructions for processor 102.

A data storage device 107 such as a magnetic disk or optical disc and its

corresponding drive may also be coupled to computer system 100 for storing information and instructions. Computer system 100 can also be coupled via bus 101 to a display device 121, such as a cathode ray tube (CRT) or Liquid Crystal Display (LCD), for displaying information to an end user. Typically, an alphanumeric input device 122, including  
5 alphanumeric and other keys, may be coupled to bus 101 for communicating information and/or command selections to processor 102. Another type of user input device is cursor control 123, such as a mouse, a trackball, or cursor direction keys for communicating direction information and command selections to processor 102 and for controlling cursor movement on display 121.

10 A communication device 125 is also coupled to bus 101. The communication device 125 may include a modem, a network interface card, or other well known interface devices, such as those used for coupling to Ethernet, token ring, or other types of physical attachment for purposes of providing a communication link to support a local or wide area network, for example. In this manner, the computer system 100 may be coupled to a  
15 number of clients and/or servers via a conventional network infrastructure, such as a company's Intranet and/or the Internet, for example.

It is appreciated that a lesser or more equipped computer system than the example described above may be desirable for certain implementations. Therefore, the configuration of computer system 100 will vary from implementation to implementation  
20 depending upon numerous factors, such as price constraints, performance requirements, technological improvements, and/or other circumstances.

It should be noted that, while the operations described herein may be performed



under the control of a programmed processor, such as processor 102, in alternative embodiments, the operations may be fully or partially implemented by any programmable or hardcoded logic, such as Field Programmable Gate Arrays (FPGAs), TTL logic, or Application Specific Integrated Circuits (ASICs), for example. Additionally, the method of the present invention may be performed by any combination of programmed general purpose computer components and/or custom hardware components. Therefore, nothing disclosed herein should be construed as limiting the present invention to a particular embodiment wherein the recited operations are performed by a specific combination of hardware components.

Figure 2 is a block diagram illustrating a conceptual view of a Java Bean testing tool for a computer system according to one embodiment of the present invention. Here, the Java Bean testing tool 202 reads an input file 201. This input file 201 includes the pathname to the program or Java Bean to be tested, names of other programs to be invoked by the program being tested, and the arguments to be passed to the programs to be invoked. The programs to be invoked may be part of an Application Program Interface (API). Additionally, this file 201 may contain special instructions to the testing tool. These instructions as well as the other contents of this file will be discussed in greater detail below with reference to Figure 5.

After reading the input file, the Java Bean testing tool 202 executes the program to be tested including invoking programs listed in the input file, passing to those programs the arguments specified, and performing any special instruction such as "loop" and "sleep" included in the input file.

Finally, the Java Bean testing tool 202 generates a results log 203. This results log 203 contains information based on results of execution of the program to be tested and the programs to be invoked by the program to be tested.

Alternatively, the present invention may be implemented on a computer telephony integration (CTI) system. Figure 3 is an example of a typical CTI system upon which one embodiment of the present invention may be implemented. In this system the Java Bean tool loads a Java Bean which communicates with a CTI server 301. Typically, this server will include many of the same features as the typical computer system described above with reference to Figure 1. For example, the CTI server 301 will likely include a processor 102, bus 101, main memory 104, read only memory 106, mass storage devices 107, a display 121, a keyboard 122, a cursor control device 123, and a communication device 125. In the CTI server 301, the communication device 125 is likely to be a network adapter. An example of equipment that can be used as a CTI server is the Aspect Communications Office Telephony Server produced by Aspect Communications, Inc.

The CTI server 301 is connected to an Automatic Call Distributor (ACD)/switch/PBX 302. The ACD switch 302 controls and routes all the calls using call control tables. Equipment that can be used as an ACD switch includes various standard ACD switches manufactured by Aspect Communications, Inc. and others. This switch 302 is then connected to various CTI network devices such as telephones 303, fax machines 304, or email 305. An application written using a Java Bean can send telephony commands to a CTI server which interprets these commands into a proprietary language understood by the switch.



server, the bean event log 404 may contain results from one or more APIs. In such a system the bean event log 404 contains information based on results of execution of the program to be tested and the programs to be invoked by the program to be tested along with date and time stamps for each entry.

5           Figure 5 is an example of an input file according to one embodiment of the present invention. In this file, comment lines 500 may be identified with a pound sign (#) as the first character of the line. This file contains the name of the program to be tested 505 and a list of programs to be invoked during execution of the program being tested and parameters to be passed to these programs 510.

10           Further, this file may contain special commands to the testing tool such as a loop command 515 or a sleep command 520. The loop command 515 instructs the tool to repeat all instructions between the loop command 515 and the subsequent endloop command 525. In this example, the sleep command and the MakeCall command located between the loop command 515 and the endloop command 525 are repeated 4 times. The  
15           sleep command 520 instructs the tool to pause for the specified time period in seconds. Such a command may be useful for pausing the test in order to wait for a response after invoking a program. In this example, a sleep command 520 is used to pause execution after a MakeCall command.

20           Figure 6 is an example of a bean event log file according to one embodiment of the present invention. The contents of such a log are based on the results of execution of an API to be tested and any programs to be invoked by the program being tested. In this example, each entry in the log is time stamped 605 and a result 610 is recorded. These

results 610 include the name of the API as well as the value returned. For example, the first entry 615 is the result of a Method1 620 instruction which returned a value of null 625.

Figure 7 is an example of a script execution log file according to one embodiment of the present invention. When implemented in a CTI system, the contents of such a log are based on the responses from the switch corresponding to the APIs invoked. In this example, each entry in the log is time stamped 705 and a result 710 is recorded. These results 710 can indicate various responses by the ACD switch to commands issued to the switch. In this example, properties of events such as message type 715, status indicator 720, and status 725 as well as others are indicated.

Figure 8 is a flow chart illustrating a Java Bean testing process according to one embodiment of the present invention. First 810, the input file is read line by line. If the specified Java Bean does not exist 815, no further processing is performed. If the specified Java Bean is located 815, the bean is loaded 820. Once the specified bean has been loaded, the API names and parameters are read from the input file 825. Each API and parameter read are then stored in an object 830 and each of these objects are then accessed 835. If the APIs do not exist in the bean 840, that is, an instance of the API object has not been created, no further processing occurs. If the APIs do exist in the bean 840, they are accessed and invoked in the order in which they appear 845. If the input file does not specify an event listener 850, a script execution log is created but is left empty. If an event listener is specified 850, events are logged in the script execution log 855 and the bean event log 860 and each entry is date and time stamped 865.



class name 1110. The listener class is then retrieved, an instance of the class is created and the instance is passed to an action listener 1115. The class then extracts API information from the add object object, invokes the API and stores the results 1120. Finally, the API results are logged with a date and time stamp 1125.

5           Figure 12 is a flow chart of a class for running Java Beans (a JarRunner class) according to one embodiment of the present invention. This class first loads the bean class 1205. Next, the listener class is loaded 1210. Finally, the class invokes all APIs listed in the input file 1215.

10           Figure 13 is a flow chart of a class for reading an input file (a LaodJarFile class) according to one embodiment of the present invention. This class first reads a file name from the command file 1305. This file is then parsed to read the bean name, listener class name, APIs and API parameters 1310. The word read is identified as either a “BeanName” 1315, “Loadlistener” 1325, “MethodName” 1335, “Parameters” 1345, “loop” 1355, “endloop” 1365, or “sleep” 1375. If the word read does not match any of these, no processing is performed. If the word read is “BeanName” 1315, the class gets the bean name and uses the name to load the bean class 1320. When the word read is “Loadlistener” 1325, the class gets the listener class name and uses it to load the listener class 1330. If the word read is a “MethodName” 1335, the class creates a new object which stores API information and the API name 1340. When the word read is “Parameters” 1345, the class gets all the parameters of the API and stores them 1350 in an object created in step 1340.

If the word read is "loop" 1355, the class invokes all APIs before loop, creates a list of APIs to be repeated, and stores the loop count 1360. When an "endloop" is read 1365, the class repeats the APIs to be repeated between loop and endloop for the given number of times 1370. If the word read is "sleep" 1375, the class gets the sleep time 1380.

Figure 14 is a flow chart of a class for writing a log file (a Logfile class) according to one embodiment of the present invention. This class logs the given string in a given file name with a date and time stamp 1405.

Figure 15 is a flow chart illustrating a class for creating a user defined object (a UserDefinedObject class) according to one embodiment of the present invention. This class stores information about a user defined object such as class name and member name 1505.